

CLAIMS

What is claimed is:

5 1. A predictive device for modeling a non-linear, causal, multiple-input single-output system or process, comprising:

a plurality of preprocessing units for receiving a working signal including control data inputs, the preprocessing units normalizing the control data inputs, resulting in preprocessed inputs;

10 a plurality of delay units coupled to the preprocessing units, the delay units time aligning the preprocessed inputs, resulting in time aligned inputs;

a plurality of filter units coupled to the delay units, the filter units being of a substantially simplified configuration as compared to a configuration based upon discrete state space equations, the filter units filtering the time aligned inputs at least according to time, resulting in filtered states;

15 a non-linear approximator coupled to the filter units and accepting the filtered states, the non-linear approximator generating a single approximator output;

20 a postprocessing unit coupled to the non-linear approximator to receive the generated approximator output, the postprocessing unit converting the single approximator output to a single device output that represents a prediction of the output of the multiple-input single-output dynamic system being modeled by the device, and

25 wherein the predictive device operates in a plurality of selectable modes including a configuration mode and multiple runtime modes that provide a generalized modeling of non-linear dynamic processes.

2. The device of Claim 1 further comprising:

a device controller coupled to the preprocessing units for providing input thereto; and

the single device output and other data generated by the predictive device, in any of the selectable modes, are received by the device controller for analysis, monitoring, optimization or control of the modeled process and/or the predictive device.

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3. The device of Claim 1 wherein the preprocessing units normalize the control data inputs by scaling and offsetting the control data inputs, resulting in preprocessed inputs.

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4. The device of Claim 1 wherein the postprocessing unit normalizes the approximator output by scaling and offsetting the approximator output, resulting in a postprocessed device output as the single device output.

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5. The device of Claim 1 wherein the plurality of selectable runtime modes includes a predictive mode in which:

(i) the predictive device receives a contiguous stream of control data inputs at asynchronous discrete base sample time; and

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(ii) the predictive device is operated once per base sample time.

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6. The device of claim 5 wherein the contiguous stream of control data inputs is passed from a device controller and the approximator output is received by the device controller for analysis, monitoring, optimization or control of the modeled process.

7. The device of Claim 1 wherein the plurality of selectable runtime modes comprises an horizon mode in which the predictive device:
- receives an externally defined sequence of trial future data inputs proceeding from a current prediction mode device state;
- 5 is operated in response to this sequence of trial data inputs producing a corresponding sequence of at least filtered states, and possible other state information; and
- stores the filtered states and other state information for use in reverse horizon mode.
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8. The device of claim 7 wherein the horizon mode is run one or more times between runs of the predictive device in the predictive mode.
9. The device of claim 7 wherein
- 15 a contiguous stream of external trial data inputs is passed to the predictive device from a device controller; and
- the predictions generated during horizon mode are received by the device controller for analysis, monitoring, optimization or control of the modeled process.
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10. The device of Claim 7 wherein the plurality of selectable runtime modes comprises a reverse horizon mode in which the predictive device uses
- (i) the filtered states and other state information from a most recent horizon mode run, and
- 25 (ii) an output path index indicating a point in a generated sequence of predictions to obtain the sensitivities of the predictive device to changes in the trial input data sequence used by the most recent horizon mode run, based upon running the predictive device backwards.

11. The device of claim 10 wherein the reverse horizon mode is run one or more times between runs of the predictive device in the predictive mode.
- 5 12. The device of claim 10 wherein
 - the predictive device sensitivities generated during reverse horizon mode are received by a device controller for analysis, monitoring, optimization or control of the modeled process.
- 10 13. The device of claim 10 wherein a device controller specifies the output path index.
14. The device of Claim 1 wherein the plurality of filter units comprise:
 - first and/or second order subfilters.
- 15 15. A computer method for modeling a non-linear, causal, multiple-input single-output, system or process, comprising the steps of:
 - (a) receiving and normalizing a working signal including control data inputs, resulting in preprocessed inputs;
 - (b) aligning the preprocessed inputs, resulting in time aligned inputs;
 - (c) using a plurality of filter units, filtering the time aligned inputs, at least according to time, resulting in filtered states;
 - (d) employing a non-linear approximator, generating an approximator output based upon the filtered states; and
 - 20 (e) converting the approximator output to a model output that represents a prediction of the output of the multiple-input single-output dynamic system being modeled by the method, in a manner that provides a general modeling of non-linear dynamic processes.
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16. The method of Claim 15 wherein the step of receiving includes receiving a contiguous stream of control data inputs from an external system, said data inputs representing measurements from the modeled process; and
- 5 further comprising the step of passing model output to an external system for analysis, monitoring, optimization or control of the modeled process.
17. The method of Claim 15 wherein the normalizing step employs a scale and offset for each input.
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18. The method of Claim 15 wherein the converting step employs a scale and offset.
19. The method of Claim 15 wherein, in a predictive mode, the step of receiving includes receiving a contiguous stream of control data inputs from an external system, said data inputs representing measurements from the modeled process;
- 15 said receiving of data inputs occurs once per base sample; and the steps (a) through (e) are performed once per base sample.
20. The method of Claim 19 further comprising the step of passing the model output to the external system for analysis, monitoring, optimization or control of the modeled process.
21. The method of Claim 15 wherein, in an horizon mode, steps (a) through (e) are iterated multiple times wherein, at each iteration, the filtered states and other state information are stored for later use.
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22. The method of Claim 21 further comprising the step of passing the model output at each iteration to an external device or method for analysis, monitoring, optimization or control of the modeled process.

5 23. The method of Claim 21 wherein, in a reverse horizon mode , steps (a) through (e) are iterated multiple times in reverse order, wherein, at each iteration
the steps employ stored information; and
calculating sensitivities of the model output for a specified iteration with
respect to changes in the predictive mode received data input at each previous
10 iteration, where said specified iteration is provided by an external system.

24. The method of Claim 23 further comprising the step of passing the calculated sensitivities at each iteration to the external device or method for analysis, monitoring, optimization or control of the modeled process.

15 25. The method of Claim 16 wherein the plurality of filter units comprise:
first and/or second order subfilters.

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